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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Aerosol and dynamic effects on the formation and evolution of pyro-clouds" *by* D. Chang et al.

Anonymous Referee #1

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This paper is a follow-on study on aerosol effects under different heat forcing conditions by conducting 2-D simulations using the Active Tracer High Resolution Atmospheric Model with a two-moment cloud microphysics parameterization. Although the different sensitivity regimes are classified and associated processes are analyzed, the results of the study are not new (some results have been the common senses for scientists in this area) and many previous studies with even more advanced microphysics have indicated similar results. Since most of those previous studies are 2-D, 2-D dynamics is very different from 3-D, and this study has an emphasis on dynamic effect, investigations with 3-D simulations would be something building on past research.

The paper does not provide further explanations for the phenomena they see (see specific comments). The introduction of the paper is poorly written (see details in

my specific comments). Most importantly, many process rates heavily depend on the process parameterizations (scheme-dependent), but there is no any discussion about those uncertainties.

The paper is misleading in wording such as fire forcing and biomass burning aerosols. What I found out eventually is that there is nothing to do that fire and biomass burning aerosols. It is just a heat forcing to produce different intensity of updrafts. See my specific comments for details.

Therefore, the paper needs very significant revisions to reach the point being accepted as a publication.

Specific comments

Introduction 1. First paragraph of introduction needs to be cleared up a lot. First, aerosol impacts on precipitation are very different for different cloud types such as shallow warm clouds and deep convective clouds. Therefore, not to be more confusing, please discuss them by separating cloud types. 2. P7779, Line 18-21: Li et al. 2008 detailed the non-monotonic behavior. Line 21-15: Qian et al. 2009 was not such study. Khain 2009 and Fan et al. 2009 are typical such studies. 3. Recent progresses on aerosol effects on convective clouds are not introduced. For example, a recent review study (Tao et al., Rev Geophys, 2012) on aerosol impacts on convective clouds is not even mentioned. A nice related paper on the relative importance of the thermodynamic and microphysical aerosol effects (Fan et al., PNAS, 2013) is missed too. Anyway, there are so many significant studies on aerosol impacts on convective clouds since 2011 in literature (Morrison, van den Heever, etc) but these progresses are not discussed at all. It is recommended that the authors do a thorough literature study of this topic. 4. The third paragraph of introduction: I do not see how your study is connected with biomass burning aerosols, only through the heat you added? Are the aerosol properties used in the study taken from biomass burning aerosols? If not, this is just a general test, not for biomass burning aerosols. 5. The motivation based on Reutter et al 2009 (as

stated in the first sentence of the abstract) is missing from the introduction.

Section 2.2: It is very confusing by saying fire forcing. I was misled by the wording and thought that a real fire situation is set up such as T, RH, and aerosol emissions from fires. Until I finished the whole section, I realized that it is not about fire forcing at all. It is just a heat forcing to produce different intensity of updrafts (if for fire, at least aerosol emissions from the heating plume should be assumed, not the uniform aerosols over the entire domain). Based on the general aerosol type and a simple heating setup, please remove all those fire forcing or biomass burning aerosols.

Section 2.3: The process analysis used here is not something new or unique. Modeling studies like this do those analyses all the time. I do not see why a section is needed to introduce the analysis. Simply, you only need 1-2 sentences to introduce the table A1 for the quantities you look at.

Section 3.2 Please use the temperature instead of Wm-2 to be more straightforward to general readers about the heating that you imposed in the experiments throughout the paper.

Section 3.2.1 Need to explain the reasons for aerosol-limited, updraft-limited and the transitional regime.

Section 3.2.2 The sensitivity of raindrop really depends on autoconversion parameterization, snow/graupel/hail productions and melting processes. All those parameterizations have very large uncertainties, especially with bulk microphysical parameterizations. For example, most of the autoconversion schemes were developed or evaluated for stratocumuls clouds. They may not be appropriate for convective clouds. All I want to say is that the authors have to be aware of all these uncertainties and discuss them accordingly.

P7789, first paragraph, it is very vague by using buffering effect to explain the less sensitivity. Please stick on processes.

Section 3.2.3 Again for frozen water content and particle numbers, ice nucleation parameterizations and drop freezing parameterizations impact them dramatically. Please connect them with the parameterizations of these processes in your model and discuss the uncertainties.

Section 3.2.4 Need to provide the reasons to explain the enhanced and suppressed rain rate regimes.

Section 3.3 I would not trust too much on those process rates since they really depend on the parameterizations of processes. I saw very different process rates between bulk and bin microphysical parameterizations and even between two 2-moment bulk schemes. Many of those sensitivities are scheme-dependent. Please discuss it.

P7798, Line 5-10: cloud radiative forcing and cloud lifetime effects are not examined in this study, what do the conclusions come from? A recent study over long time scale (Fan et al., 2013) suggested significant aerosol effects on deep convective cloud morphology and lifetime.

Minor comments: 1. p7783 Line 16, how do you get 85 km with 110 grids of 500 meter spacing? 2. Please use correct terminology: cloud freezing should be “drop freezing”, depositional growth of droplets should be “condensational growth of droplets”.

Interactive comment on Atmos. Chem. Phys. Discuss., 14, 7777, 2014.